

# OpenTrack simulation for suburban tunnel in Paris (RER B & D)

Presentation  
Opentrack – Viriato workshop  
January 24th, 2008  
Zurich, Switzerland



# Table of contents

17/09/07 January 24<sup>th</sup>, 2008



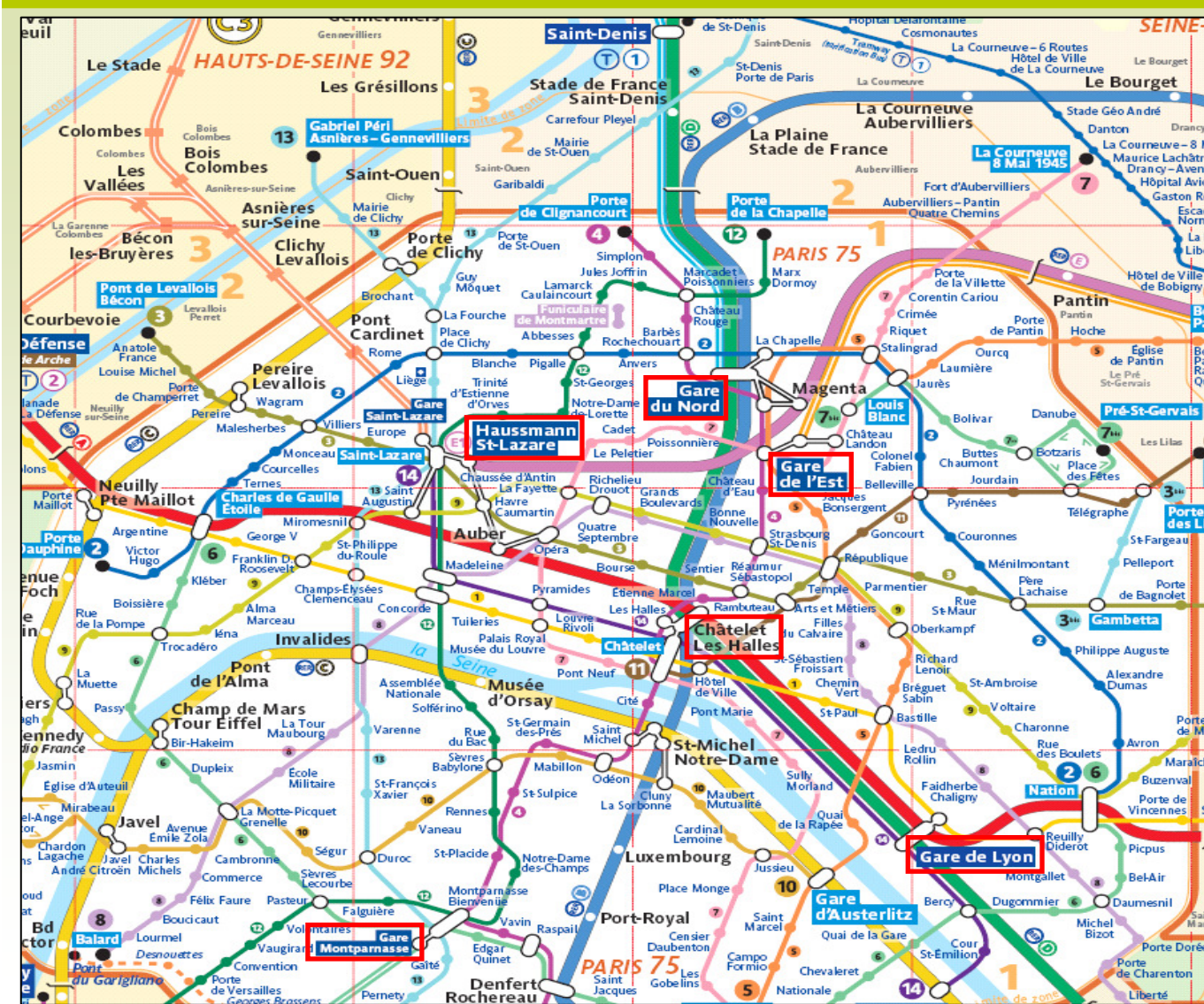
- ▶ **Introduction**
- ▶ **Overall context**
- ▶ **Main technical data**
- ▶ **Major stakes**
- ▶ **Before simulating : our method**
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- ▶ **Interesting scenarios**
- ▶ **Conclusion**





# 1. Introduction : Dense transport network

17/09/07 January 24<sup>th</sup>, 2008



## Inside Paris

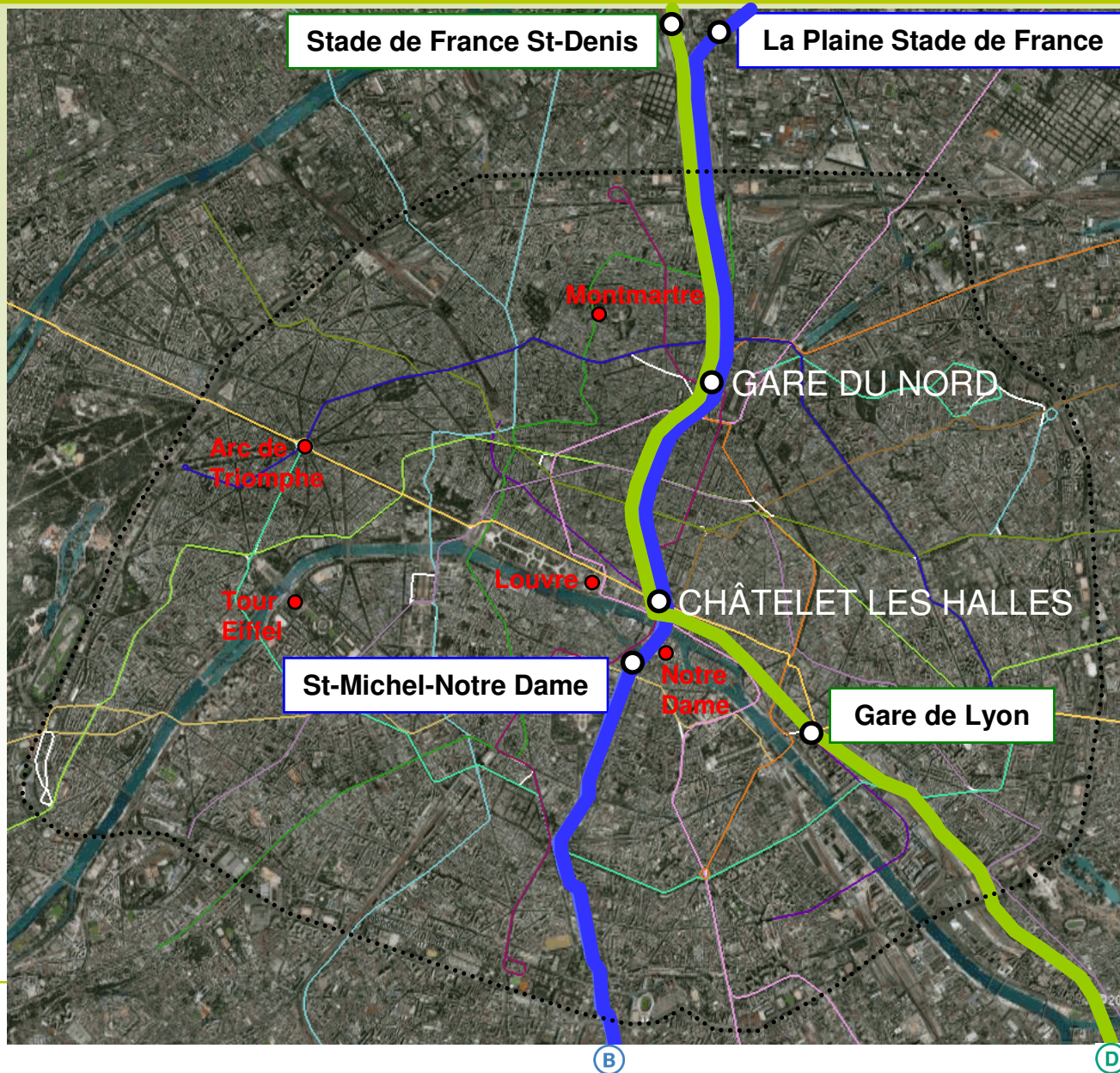
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16 lines (1 automated),  
211 km, 300 stations
- **Regional trains crossing the city :**  
5 lines, 31 stations





# 1. Introduction : Project location

17/09/07 January 24<sup>th</sup>, 2008



Gare du Nord +  
Châtelet les Halles :  
2 major nodes in  
the Paris transport  
network



## 2. Overall context

17/09/07 January 24<sup>th</sup>, 2008



- ☞ Operating problem :
  - ☞ Convergence of 2 overcrowded lines on the same double track tunnel
  - ☞ Regularity and customer satisfaction declining
  - ☞ Choices to be made by the Transport Authority to improve fluidity
  
- ☞ Client : Syndicat des Transports d'Ile de France (STIF)
  - ☞ Transport authority of Ile de France region
  
- ☞ Technical partners : the operators running trains in the tunnel
  - ☞ RATP (Paris region transport company) → southern part of line B
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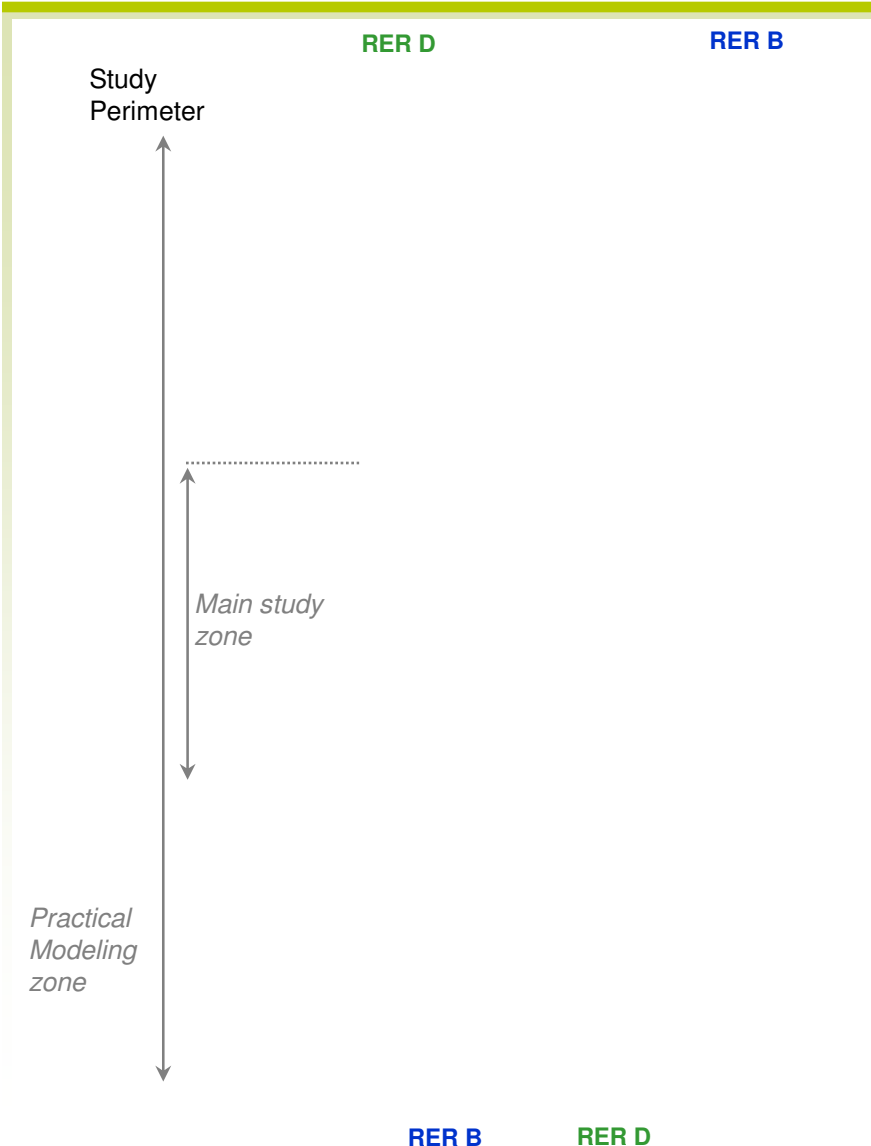


**OPENTRACK**



# 3. Main technical data

17/09/07 January 24<sup>th</sup>, 2008



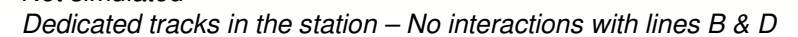
- ☞ Timetable : 32 trains per hour per direction = 20 trains line B + 12 trains line D
- ☞ Headway : 90 secondes, theoretical headway < 90 sec
- ☞ Two controlling stations (RATP & SNCF)
- ☞ Two types of rolling stock
- ☞ Two electrical power supply systems (change at Gare du Nord)
- ☞ Driver change for line B at Gare du Nord (change between RATP and SNCF)
- ☞ Use of an « extra track » in Châtelet station, called « voie Z » by line D.





## A circular collage featuring a woman's face, a high-speed train, and a cityscape. The woman's face is at the top, looking directly at the viewer. Below her, a high-speed train is shown in motion, with a blurred background suggesting speed. The bottom part of the collage shows a cityscape with buildings and a bridge.

👉 Focus on station : Châtelet-les-Halles

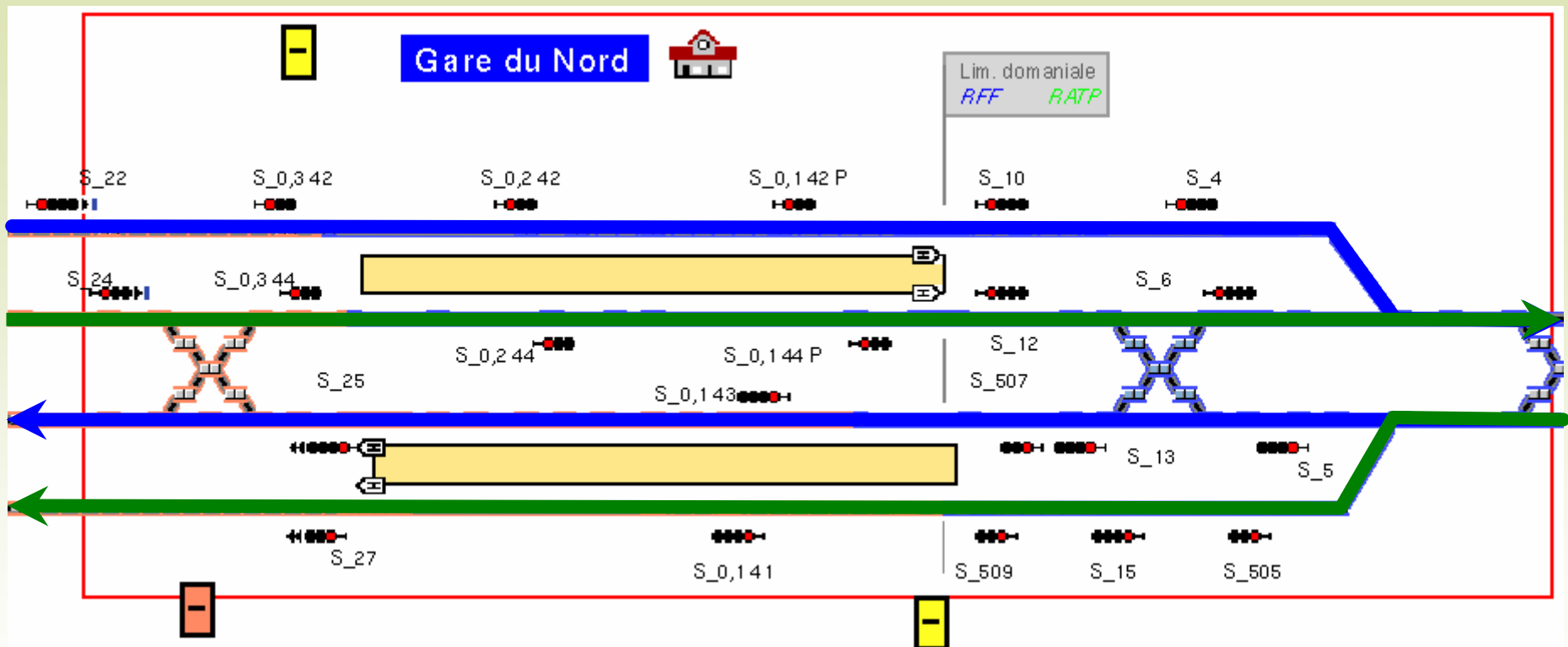


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Focus on station : Gare du Nord



(north) La Plaine Stade de France ⇌  ⇌ St Michel Notre Dame (south)

(north) Stade de France – St Denis ⇌  ⇌ Paris Gare de Lyon (south)





# 4. Major stakes

17/09/07 January 24<sup>th</sup>, 2008



- ☞ Dense traffic → one of the most heavily occupied railway sections in France
  - ☞ 32 trains per hour and per direction
  - ☞ Gare du Nord + Châtelet les Halles : 2 major nodes in Paris network
- ☞ Signalling system in the tunnel
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Diagnostic and analysis of present operations, normal situation without major disturbances

## ➡ Theoretical timetable

- ➡ Number of trains
- ➡ Different headways (ex : a train every 3 min for line B)
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**32 trains  
p.h.p.d.  
in theory**

## ➡ Real operating data (statistics concerning a representative period)

- ➡ Distribution of delays on arrival at stations
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- ➡ Use of track Z in Châtelet station
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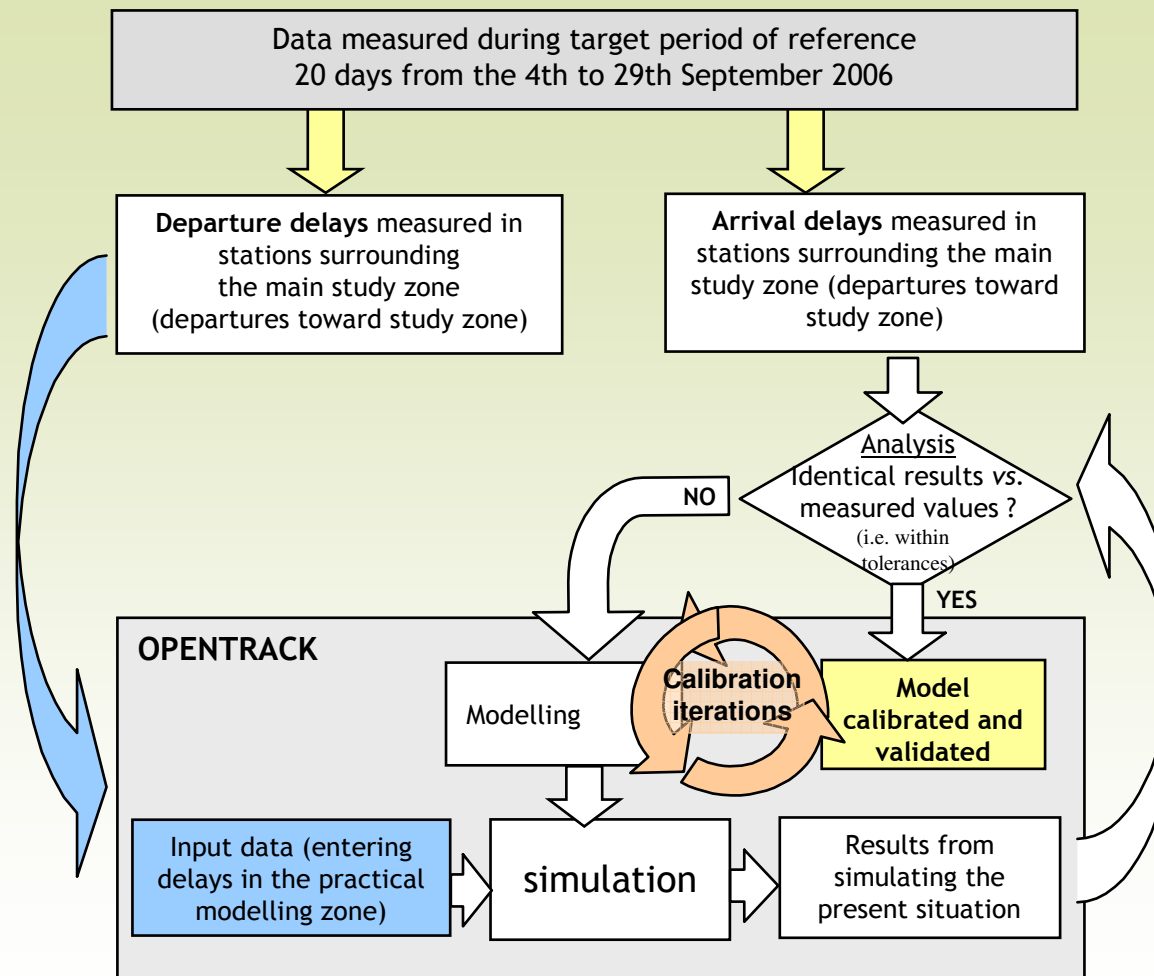
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17/09/07 January 24<sup>th</sup>, 2008





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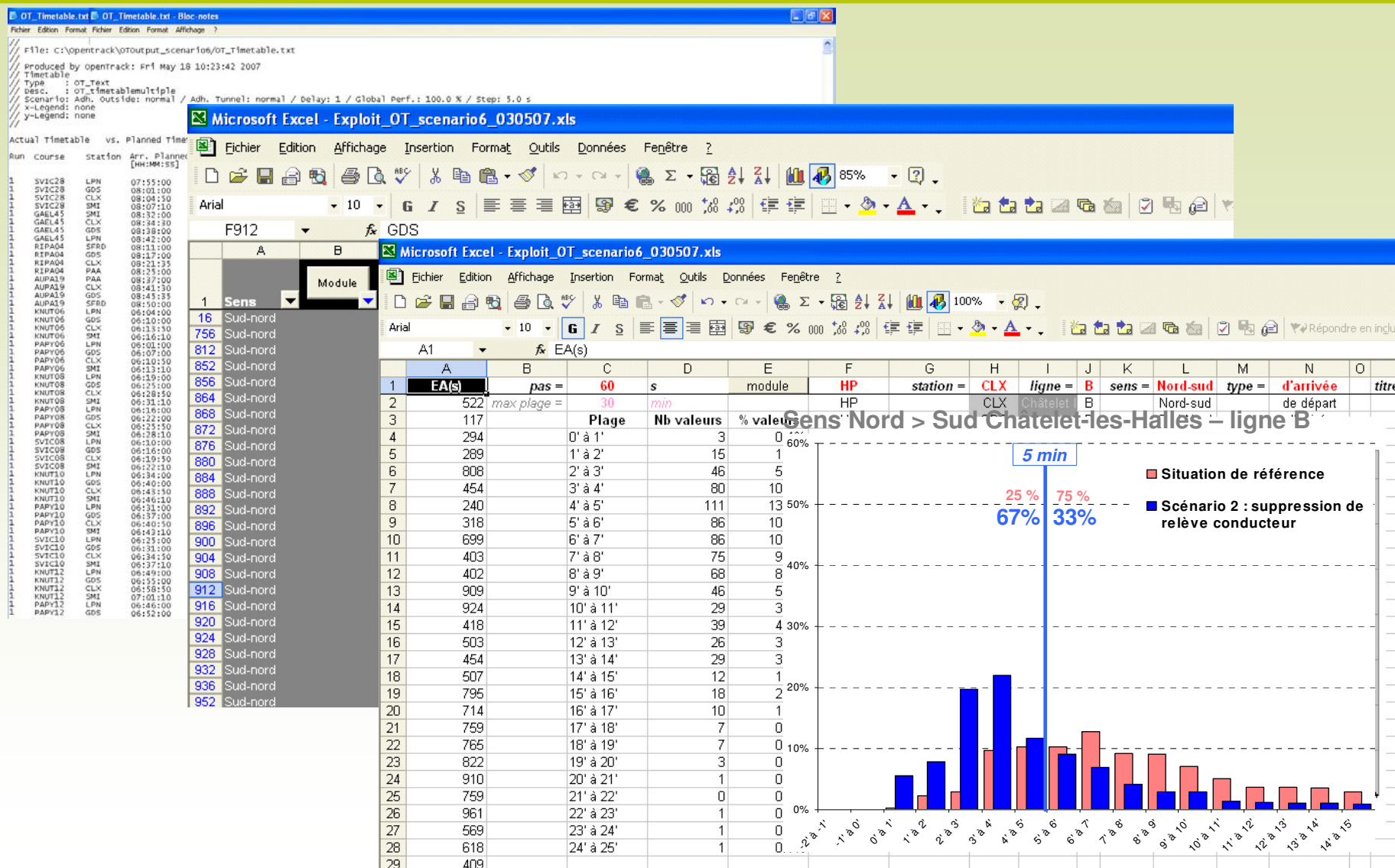
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17/09/07 January 24<sup>th</sup>, 2008



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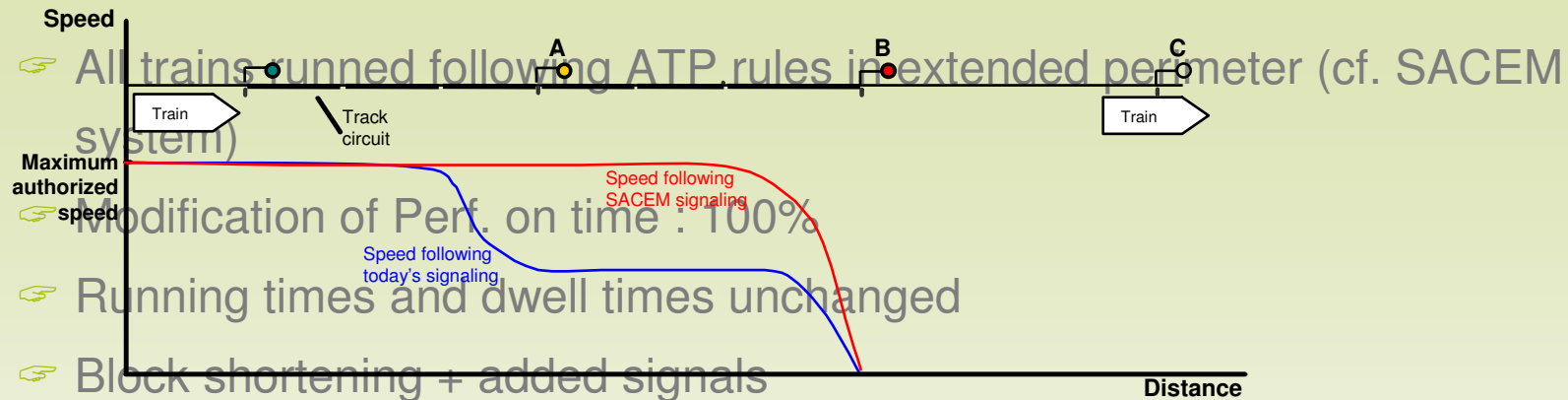


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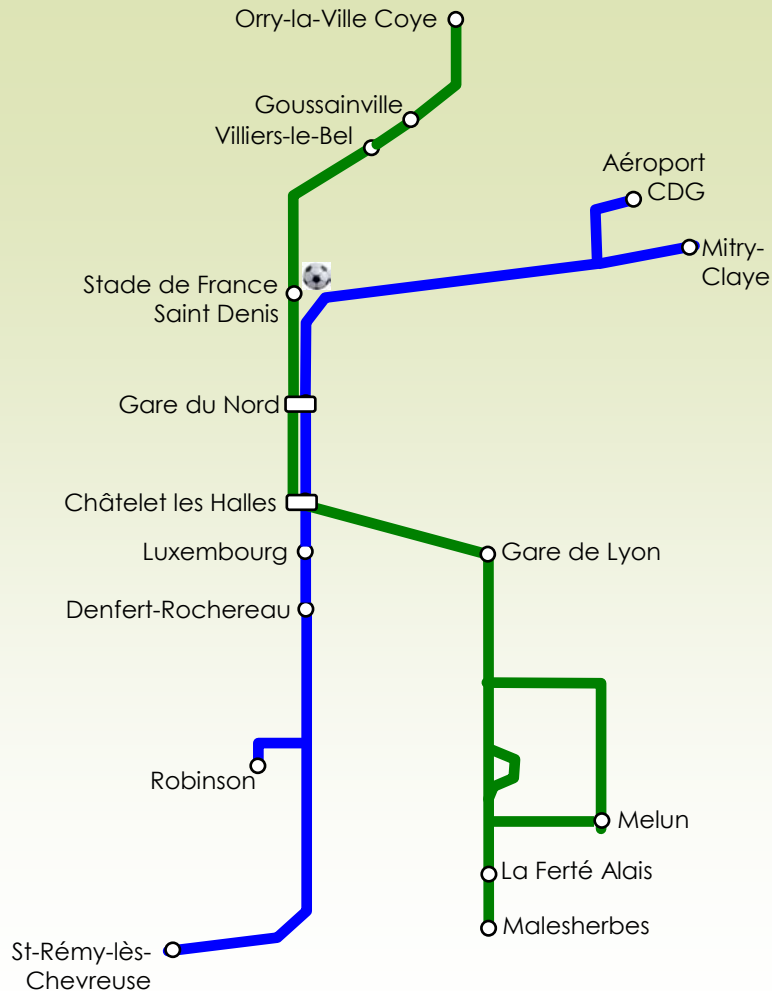
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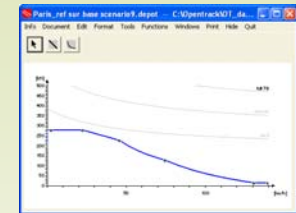


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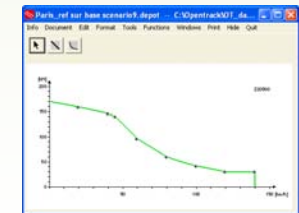
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- V max : 140 km/h
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- Length : 104 m
- Weight : 283 T
- Concerned line : RER B  
*(also running on line A)*

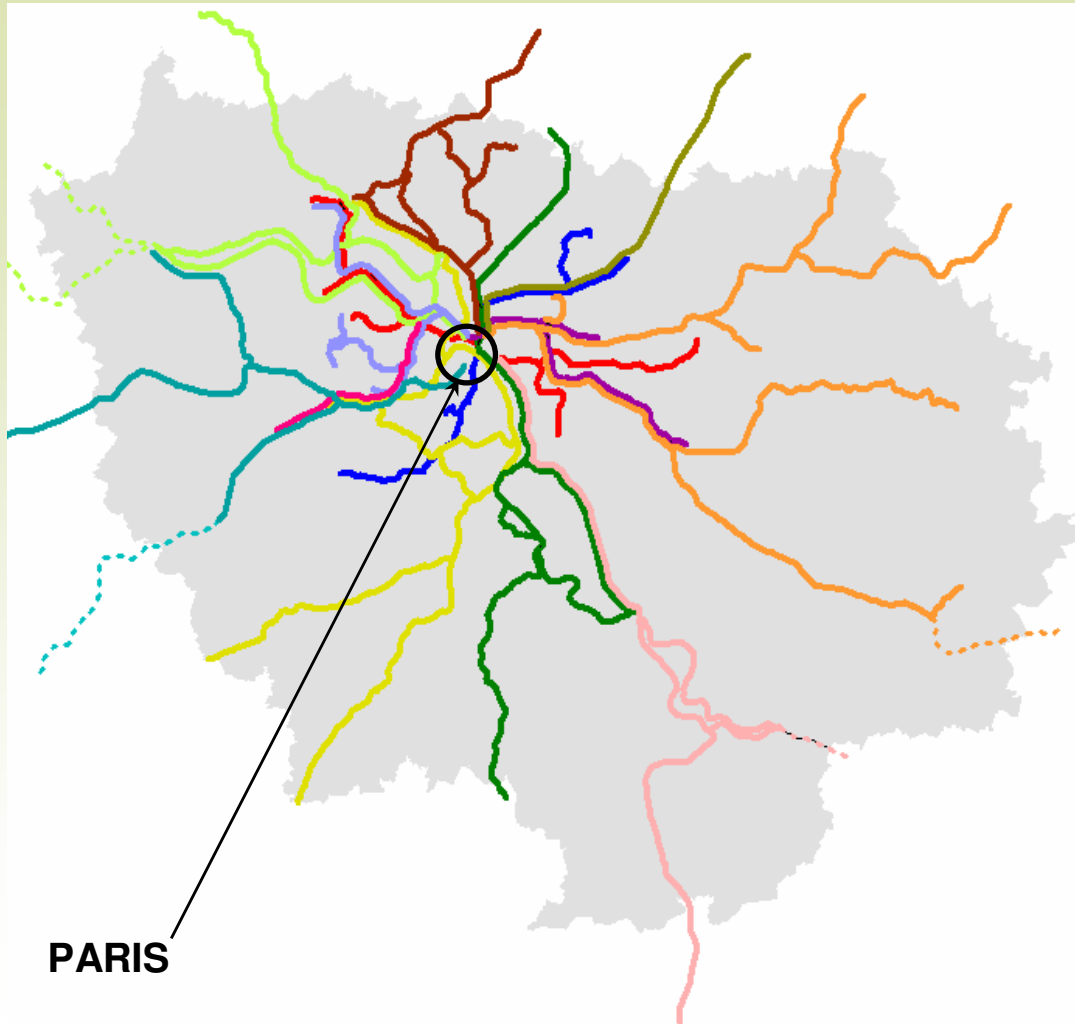


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# Ile-de-France regional rail network

17/09/07 January 24<sup>th</sup>, 2008



- Réseau Express Régional
- Strong and identified network
- Paris underground cross-over
- 2 operators : RATP + SNCF



- SNCF operation (Transilien)
- Basic commuter lines
- Terminus in 6 main stations
- Possible shared trunks with RER lines



# 7. Other scenarios – selected list

17/09/07 January 24<sup>th</sup>, 2008



## ☞ Basic scenarios

- ☞ Equal RS performances for both lines
- ☞ Modification of line D headway
- ☞ 2<sup>nd</sup> tunnel between surrounding stations
- ☞ Modification of injection following improvements outside perimeter

## ☞ Combined scenarios



# What is Egis Rail ?

17/09/07 January 24<sup>th</sup>, 2008



**Europe's major financial institution, N°1 French financial group**



**A French consulting, engineering and operating firm, dedicated to development infrastructures**



**Rail and transit consultants and engineers, formerly named SEMALY, created in 1968**

**Covering all types of transport projects**

- Metro
- Light Rail Transit
- Conventional Rail
- High Speed Lines

**For the benefit of**

- Ministries of Transport
- Regional or City Authorities
- Operators
- Private Consortia, etc...



# Egis Rail ? Range of services

17/09/07 January 24<sup>th</sup>, 2008



- Planning studies, Consultancy and Audits
- Design
- Procurement assistance
- Construction management and supervision
- Manufacturing control
- Testing and commissioning
- Maintenance management





# Egis Rail ? References

17/09/07 January 24<sup>th</sup>, 2008



## ☞ METRO



**LYON** : whole network  
(line D, fully automated)

Tunnel boring  
machine



**MARSEILLES**  
Extension of the network



# Egis Rail ? References

17/09/07 January 24<sup>th</sup>, 2008



## ☞ LIGHT RAIL TRANSIT



**DUBLIN:** Technical Design  
& Construction Management



**KRAKOW :** design assistance  
and construction supervision



**OPORTO:** integrated engineering  
within a private Consortium





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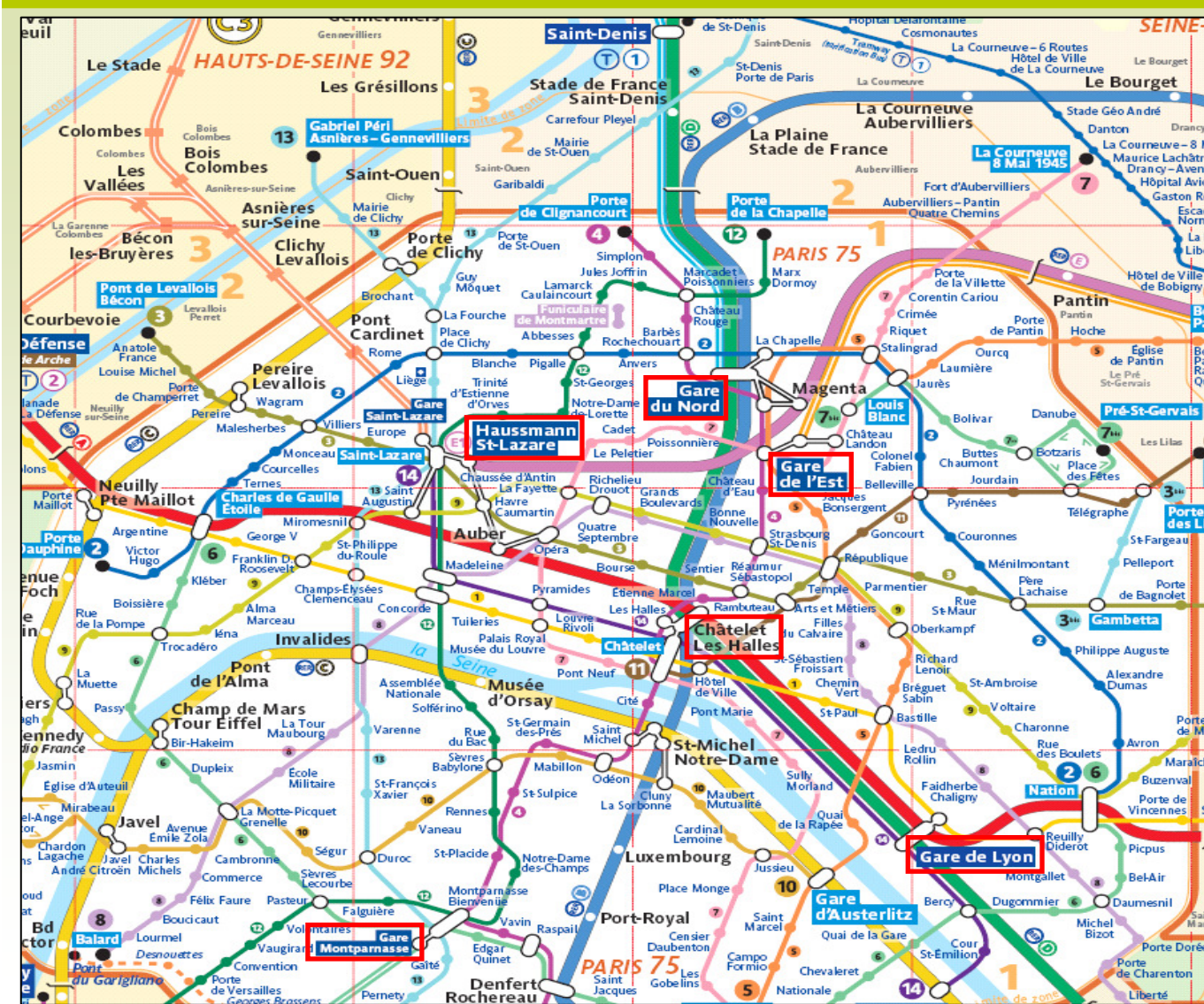
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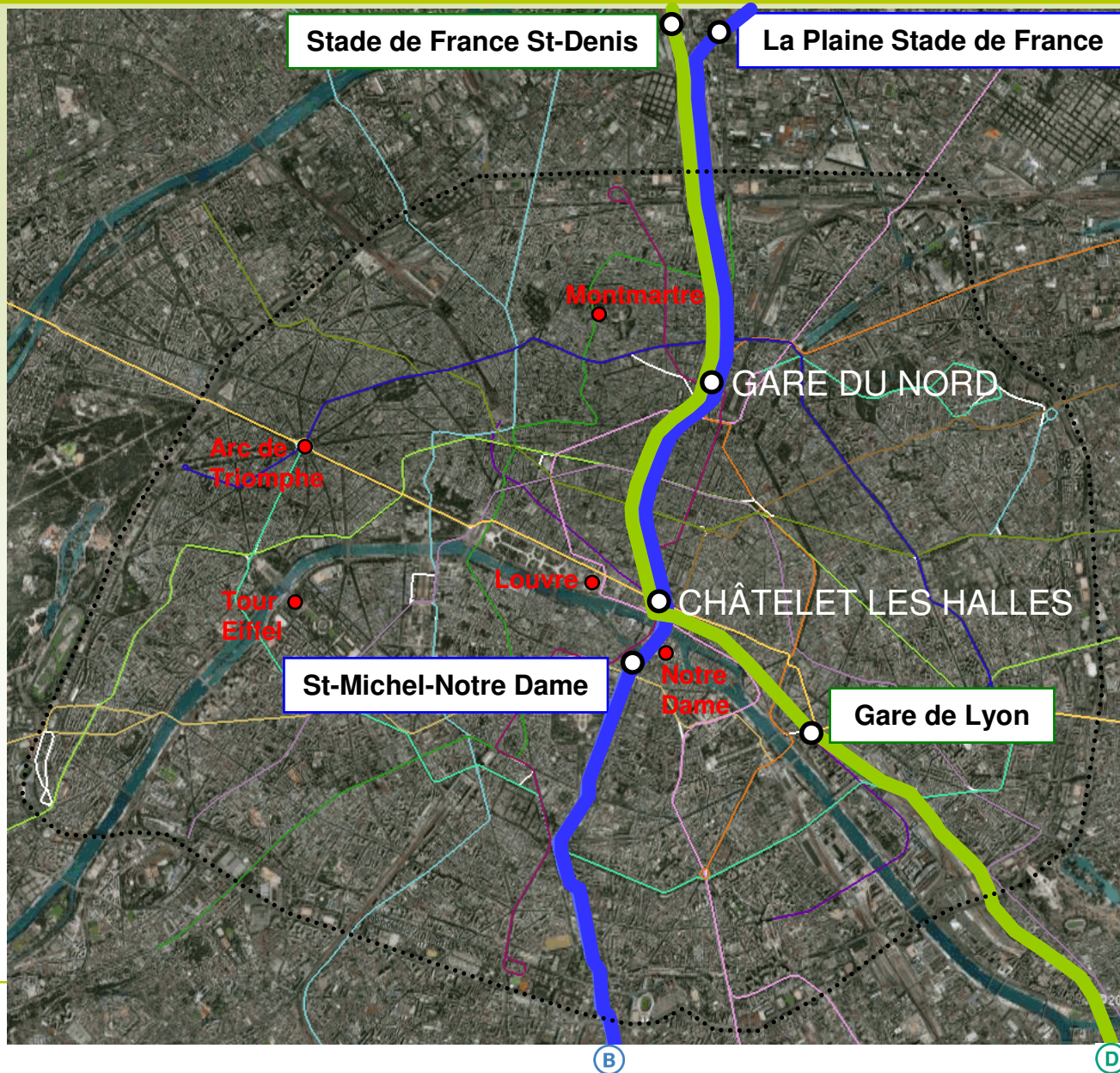
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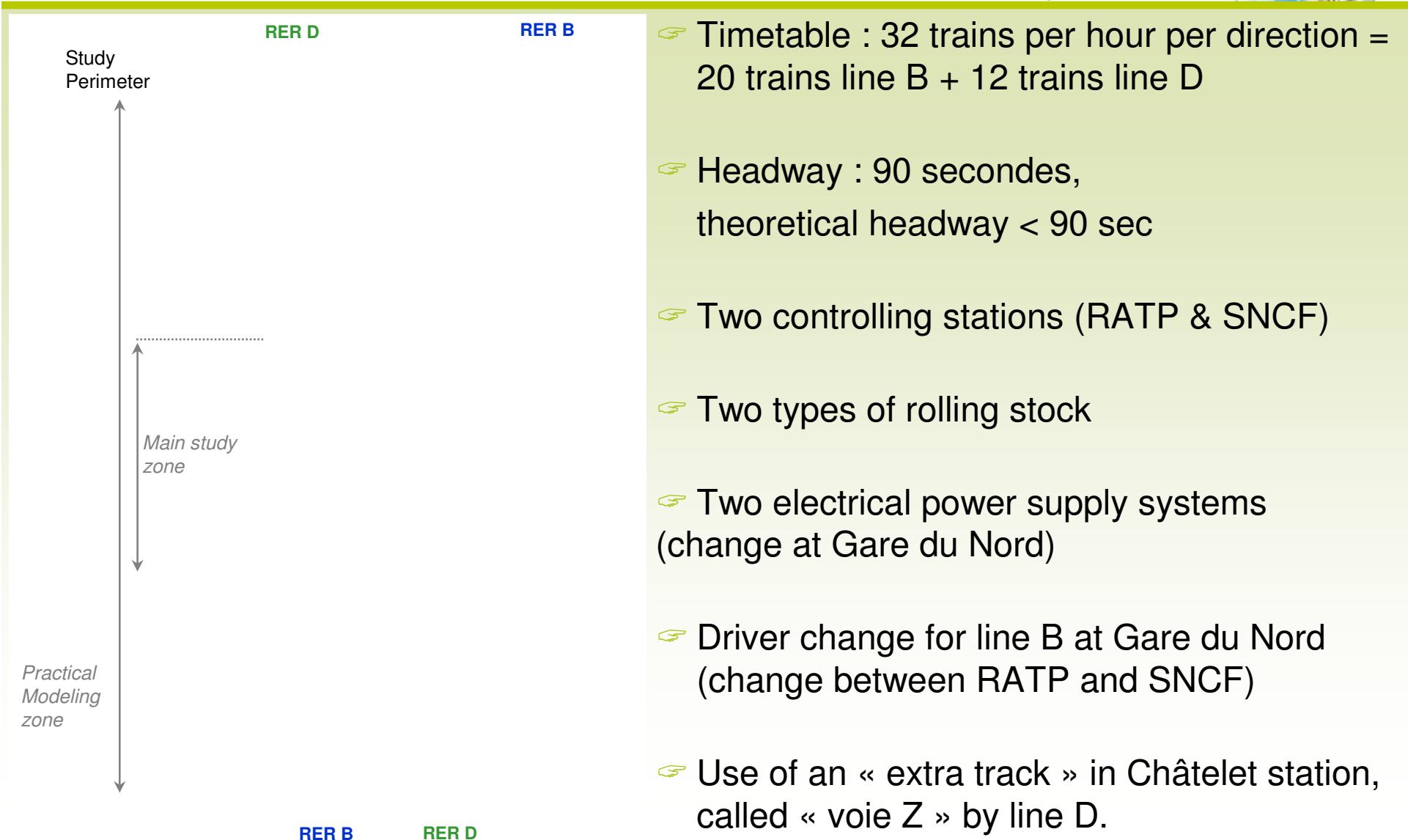


**OPENTRACK**



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17/09/07 January 24<sup>th</sup>, 2008



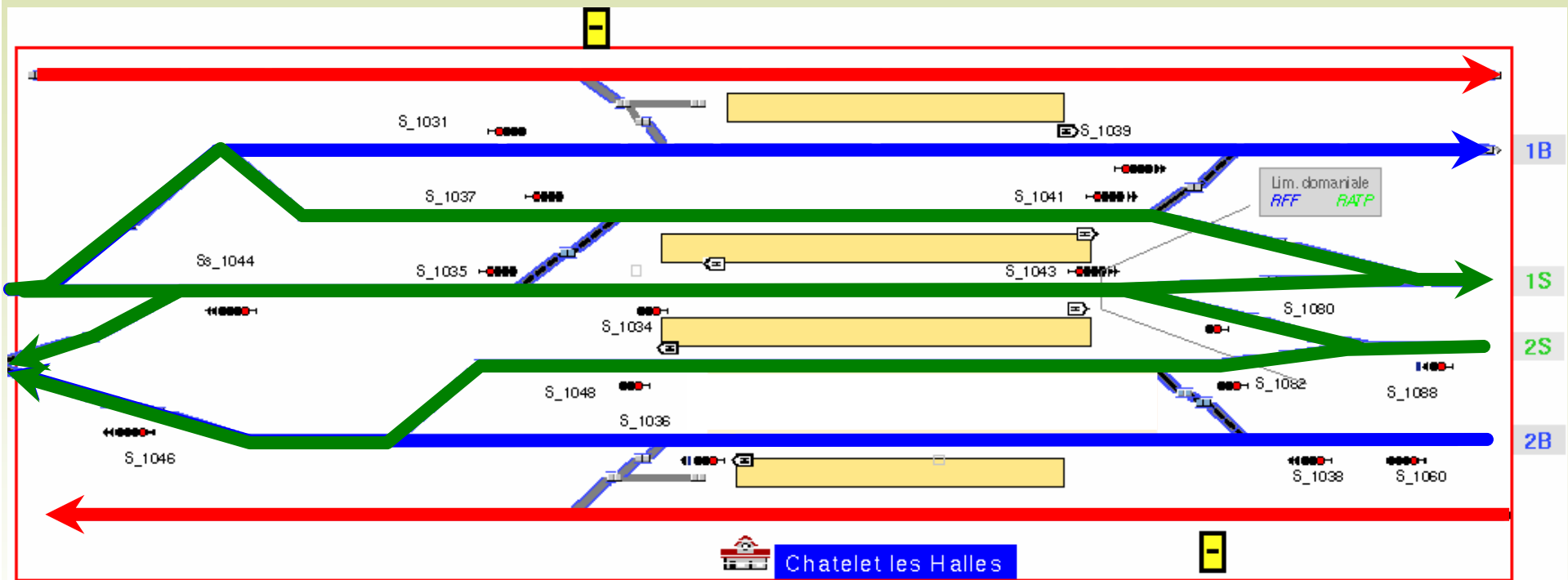


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*Not simulated*

*Dedicated tracks in the station – No interactions with lines B & D*

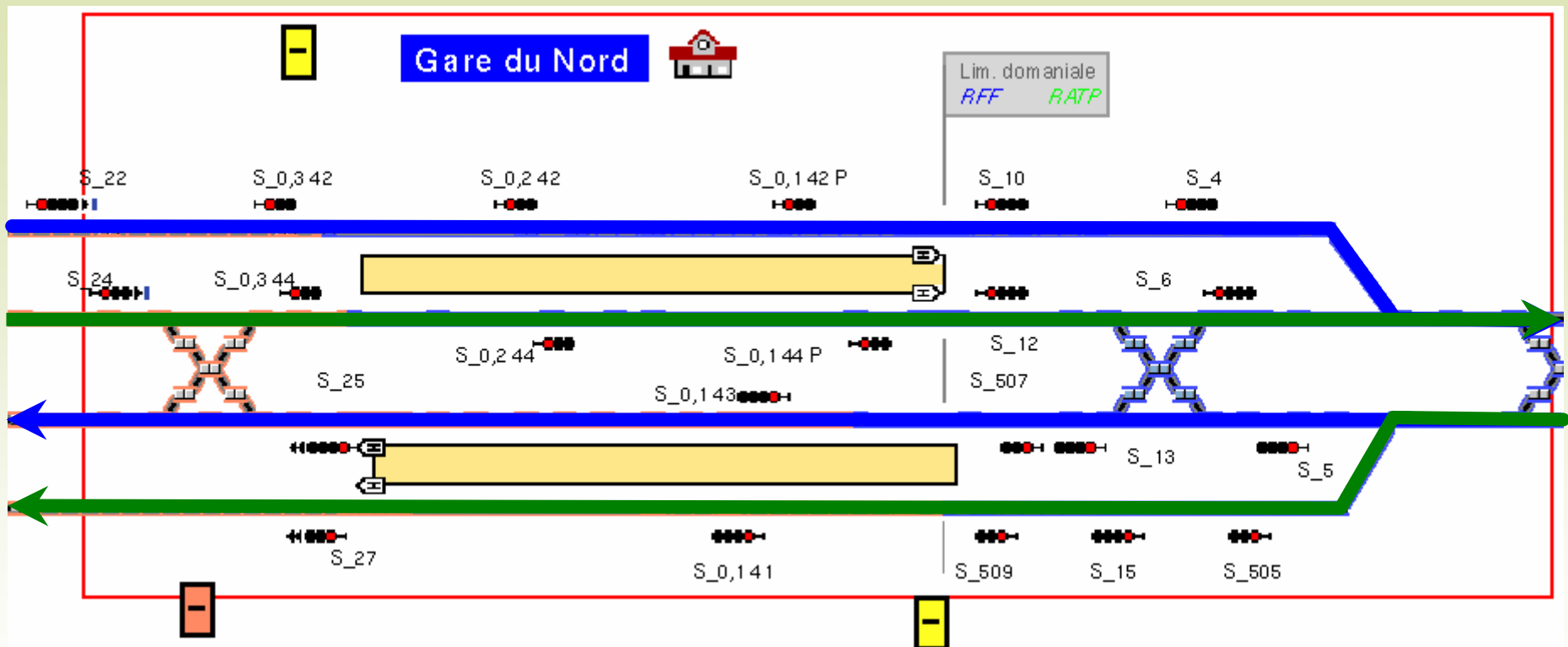


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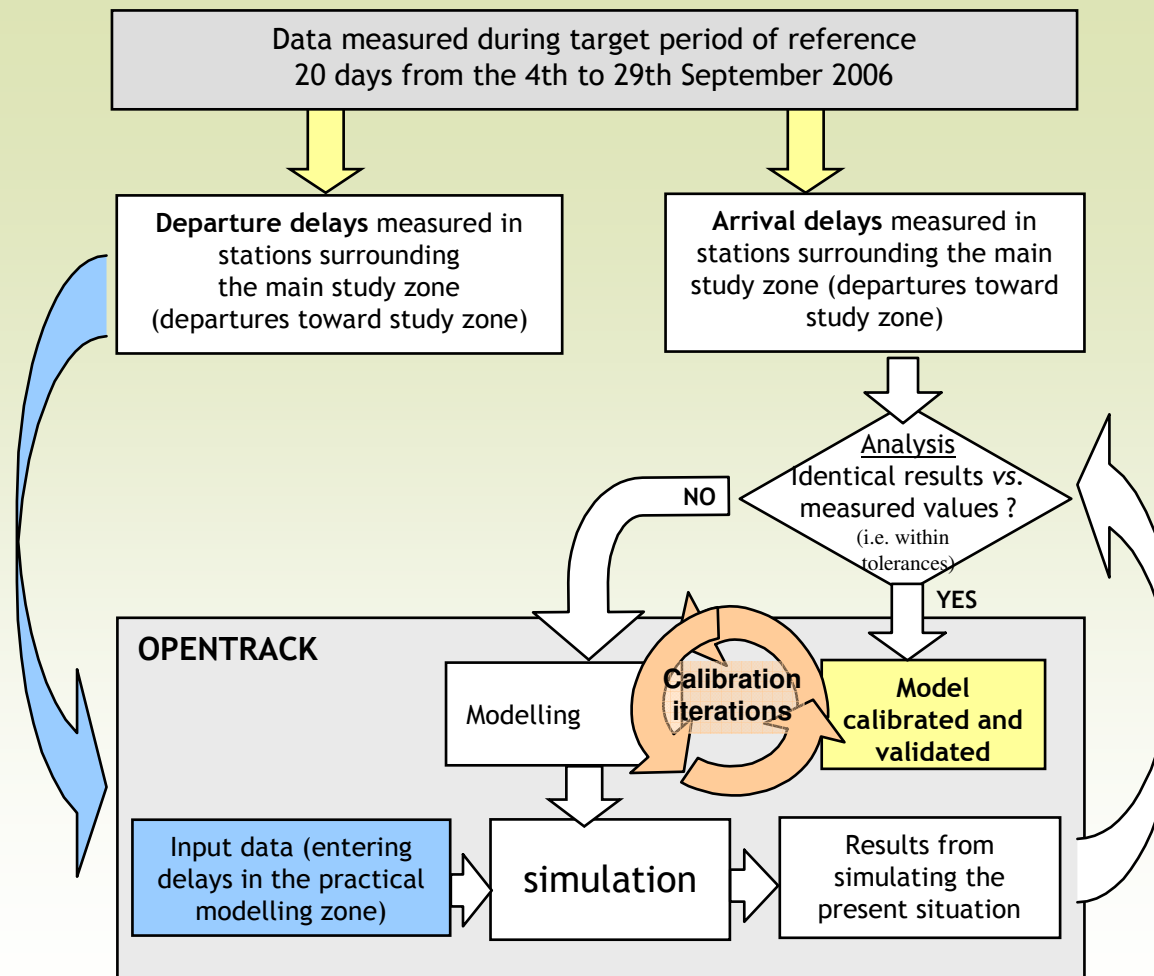
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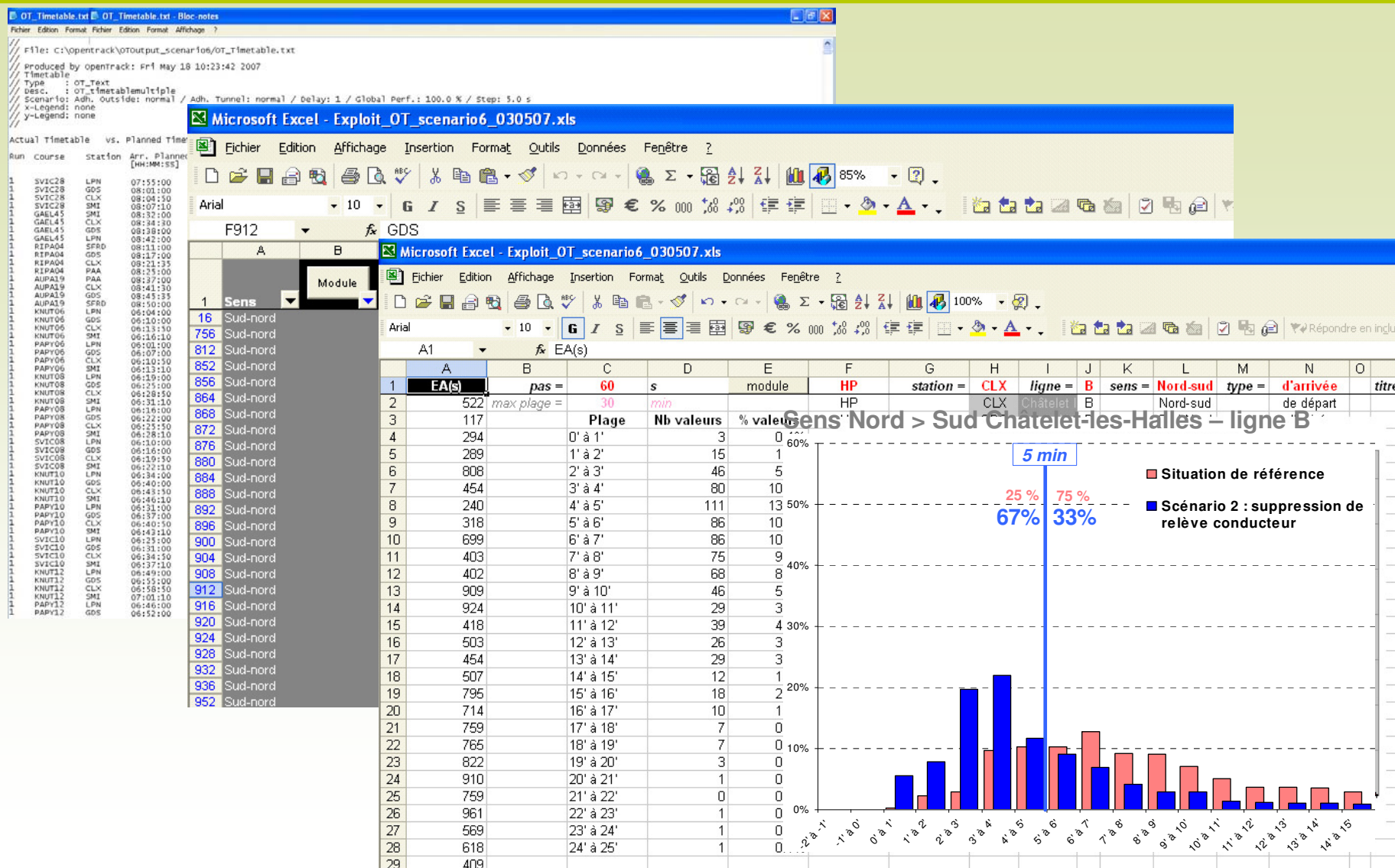


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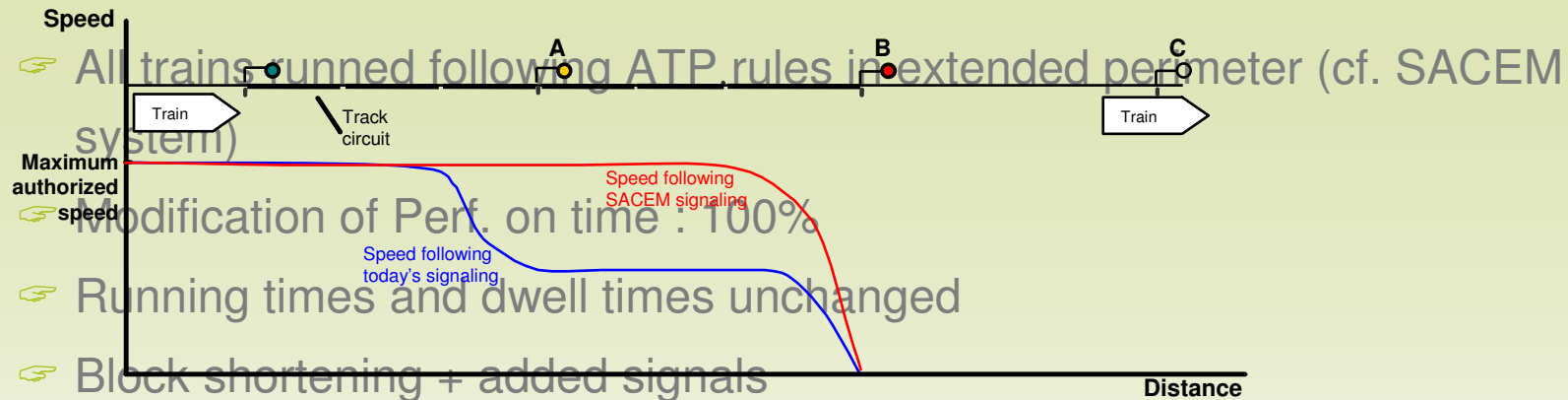


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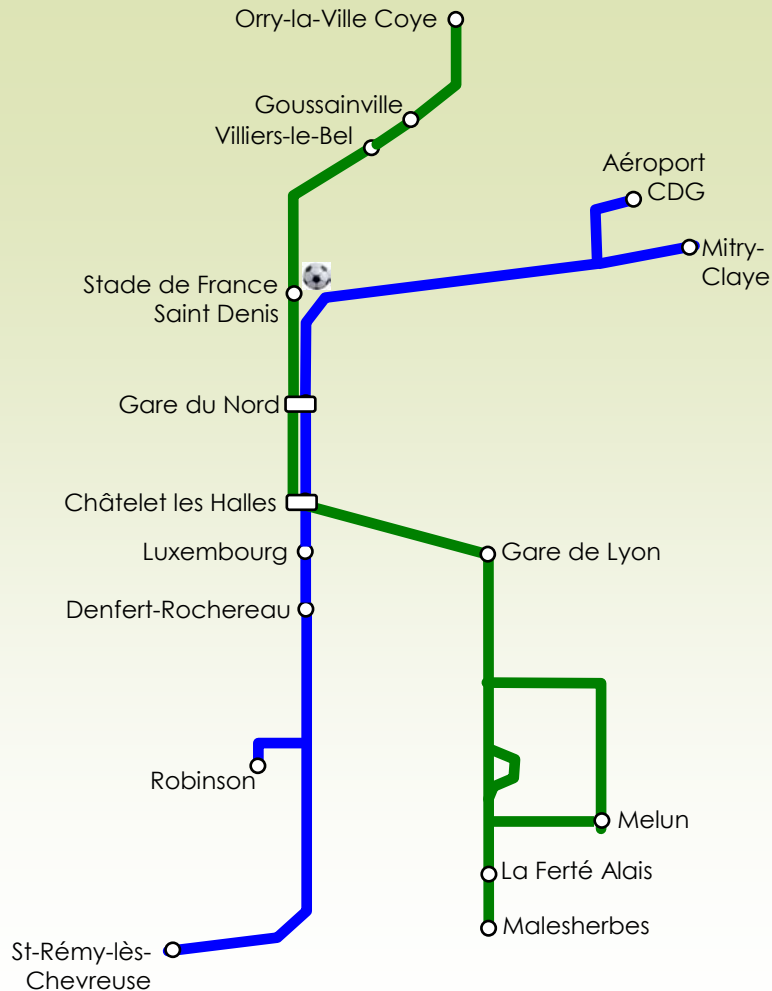
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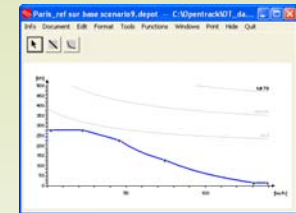


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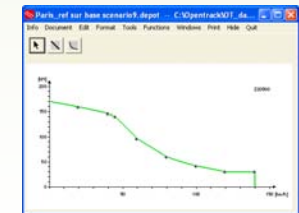
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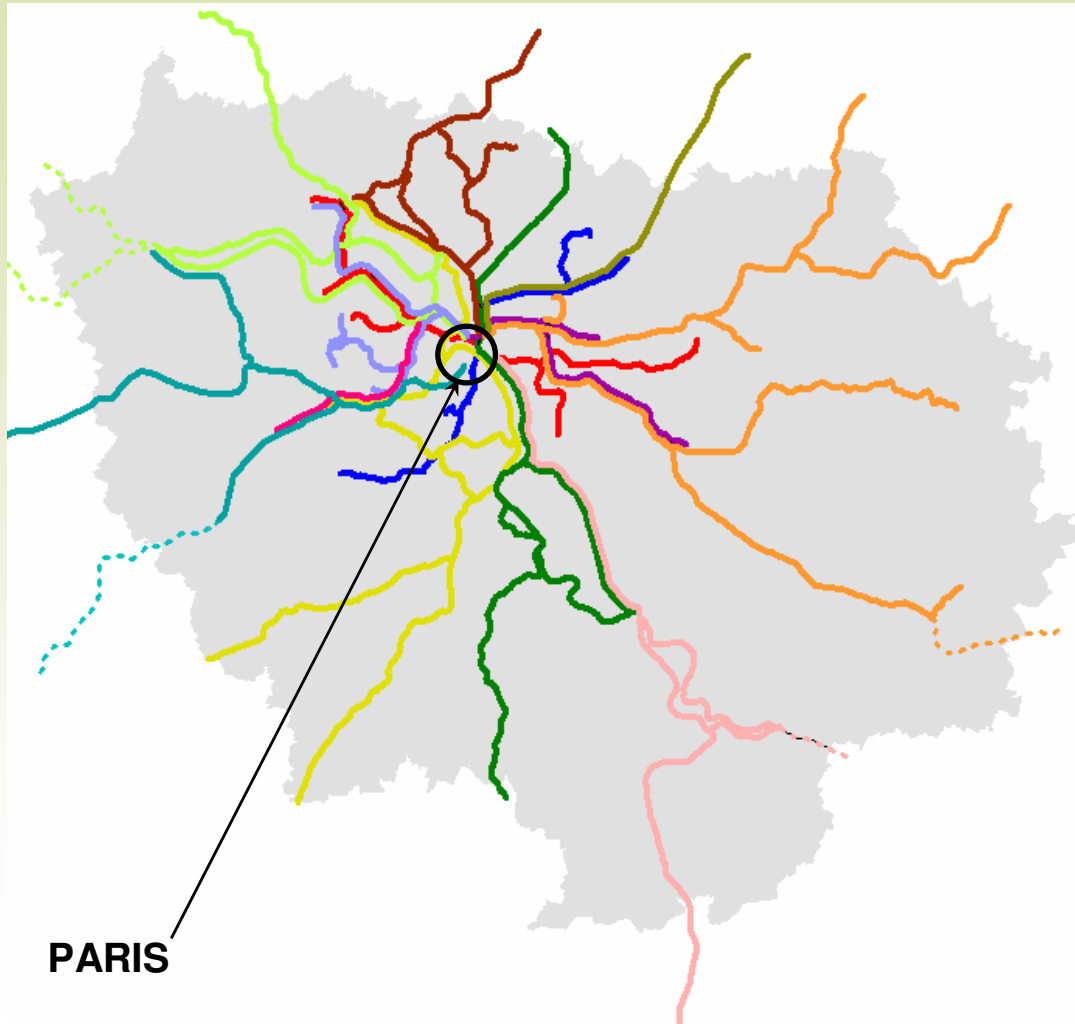


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17/09/07 January 24<sup>th</sup>, 2008



## ☞ Basic scenarios

- ☞ Equal RS performances for both lines
- ☞ Modification of line D headway
- ☞ 2<sup>nd</sup> tunnel between surrounding stations
- ☞ Modification of injection following improvements outside perimeter

## ☞ Combined scenarios





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17/09/07 January 24<sup>th</sup>, 2008



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**A French consulting, engineering and operating firm, dedicated to development infrastructures**



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17/09/07 January 24<sup>th</sup>, 2008



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- Construction management and supervision
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# Egis Rail ? References

17/09/07 January 24<sup>th</sup>, 2008

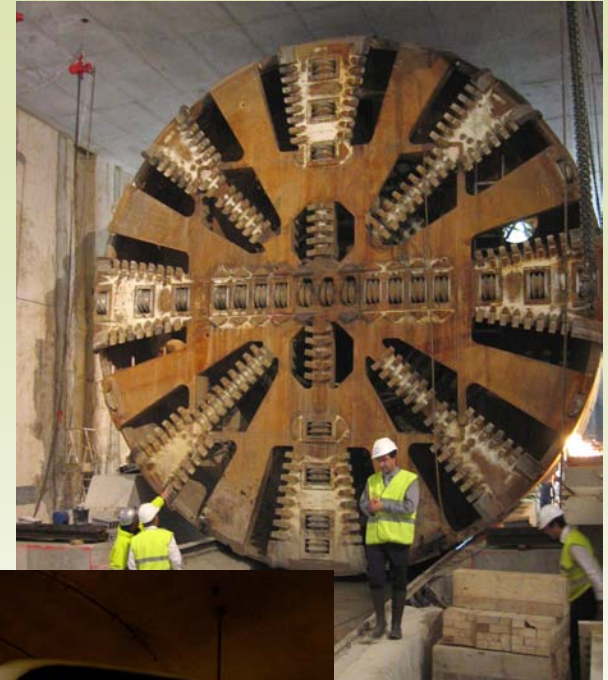


## ☞ METRO



**LYON** : whole network  
(line D, fully automated)

Tunnel boring  
machine



**MARSEILLES**  
Extension of the network





# Egis Rail ? References

17/09/07 January 24<sup>th</sup>, 2008



## ☞ LIGHT RAIL TRANSIT



**DUBLIN:** Technical Design  
& Construction Management



**KRAKOW :** design assistance  
and construction supervision



**OPORTO:** integrated engineering  
within a private Consortium



# OpenTrack simulation for suburban tunnel in Paris (RER B & D)

Presentation  
Opentrack – Viriato workshop  
January 24th, 2008  
Zurich, Switzerland





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17/09/07 January 24<sup>th</sup>, 2008

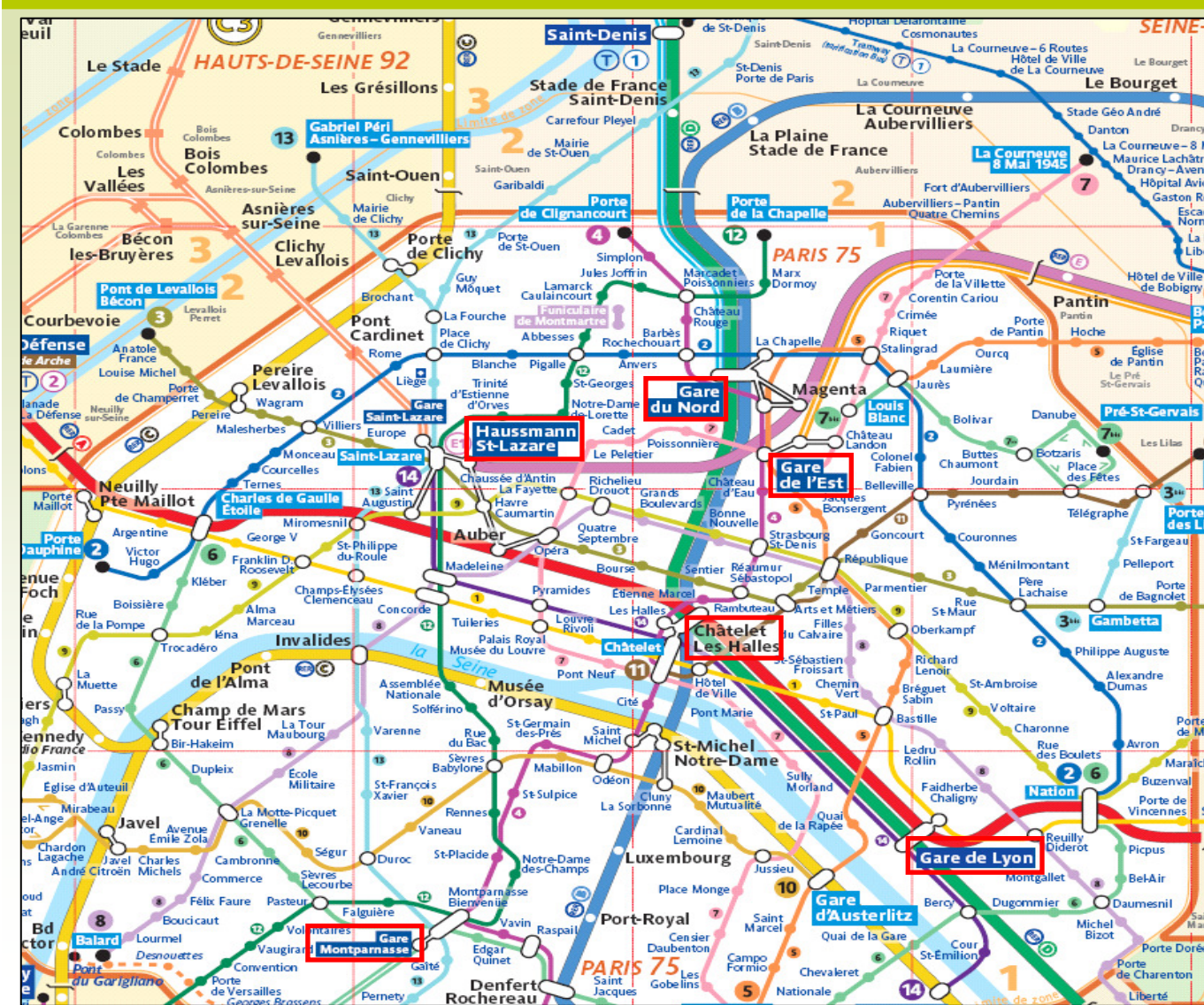


- ▶ **Introduction**
- ▶ **Overall context**
- ▶ **Main technical data**
- ▶ **Major stakes**
- ▶ **Before simulating : our method**
- ▶ **Simulation in several steps**
- ▶ **Interesting scenarios**
- ▶ **Conclusion**



# 1. Introduction : Dense transport network

17/09/07 January 24<sup>th</sup>, 2008



## Inside Paris

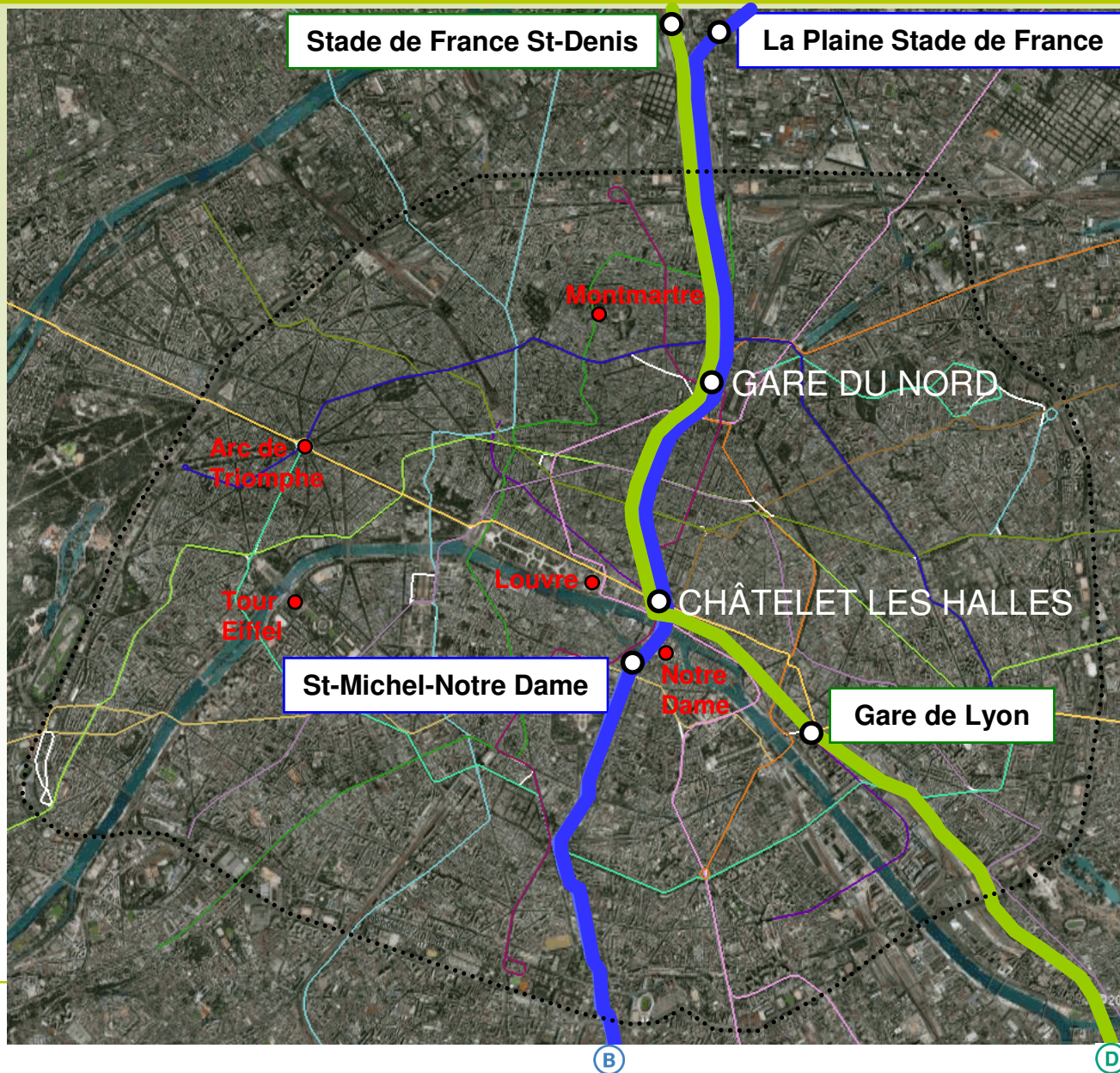
- **Underground :**  
16 lines (1 automated),  
211 km, 300 stations
- **Regional trains crossing the city :**  
5 lines, 31 stations





# 1. Introduction : Project location

17/09/07 January 24<sup>th</sup>, 2008



Gare du Nord +  
Châtelet les Halles :  
2 major nodes in  
the Paris transport  
network



## 2. Overall context

17/09/07 January 24<sup>th</sup>, 2008



- ☞ Operating problem :
  - ☞ Convergence of 2 overcrowded lines on the same double track tunnel
  - ☞ Regularity and customer satisfaction declining
  - ☞ Choices to be made by the Transport Authority to improve fluidity
  
- ☞ Client : Syndicat des Transports d'Ile de France (STIF)
  - ☞ Transport authority of Ile de France region
  
- ☞ Technical partners : the operators running trains in the tunnel
  - ☞ RATP (Paris region transport company) → southern part of line B
  - ☞ SNCF : National railway company → northern part of line B & line D
  
- ☞ Support : Mr Huerlimann – OpenTrack GmbH

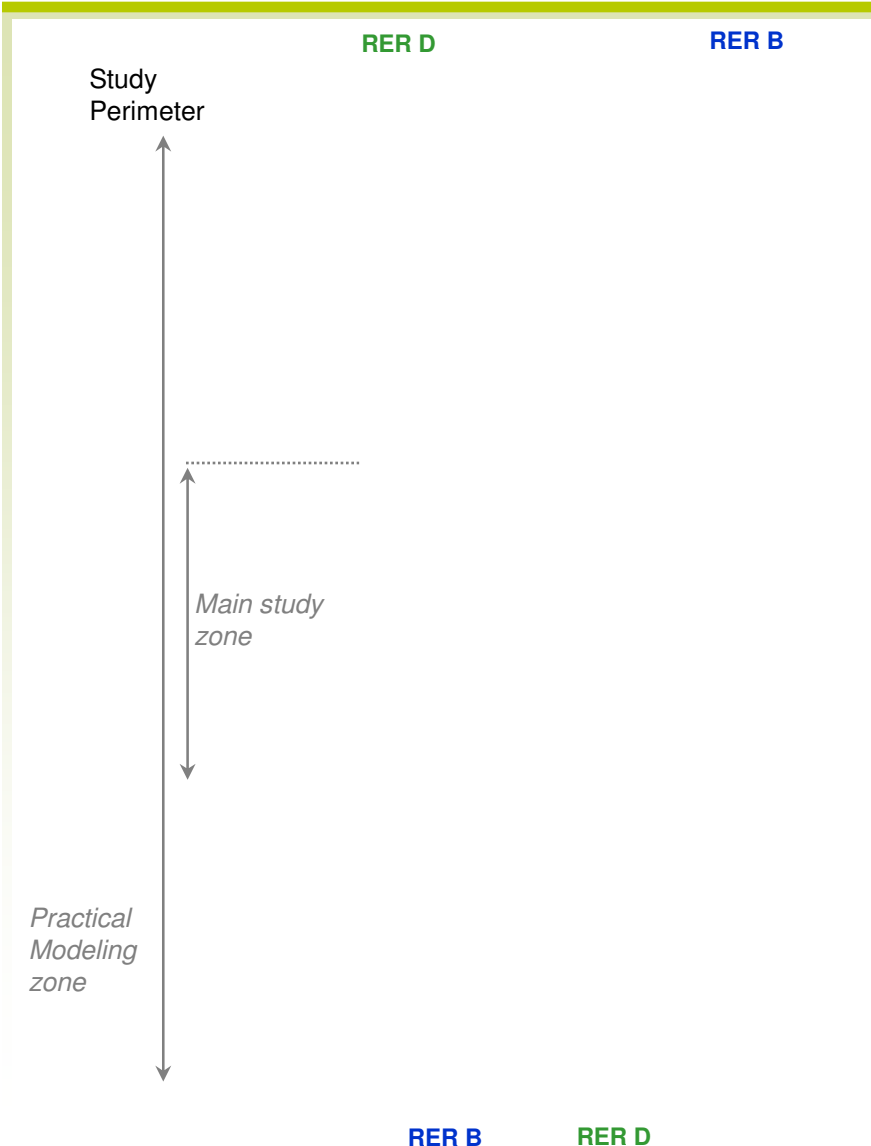


**OPENTRACK**



# 3. Main technical data

17/09/07 January 24<sup>th</sup>, 2008



- ☞ Timetable : 32 trains per hour per direction = 20 trains line B + 12 trains line D
- ☞ Headway : 90 secondes, theoretical headway < 90 sec
- ☞ Two controlling stations (RATP & SNCF)
- ☞ Two types of rolling stock
- ☞ Two electrical power supply systems (change at Gare du Nord)
- ☞ Driver change for line B at Gare du Nord (change between RATP and SNCF)
- ☞ Use of an « extra track » in Châtelet station, called « voie Z » by line D.





👉 Focus on station : Châtelet-les-Halles



*Dedicated tracks in the station – No interactions with lines B & D*

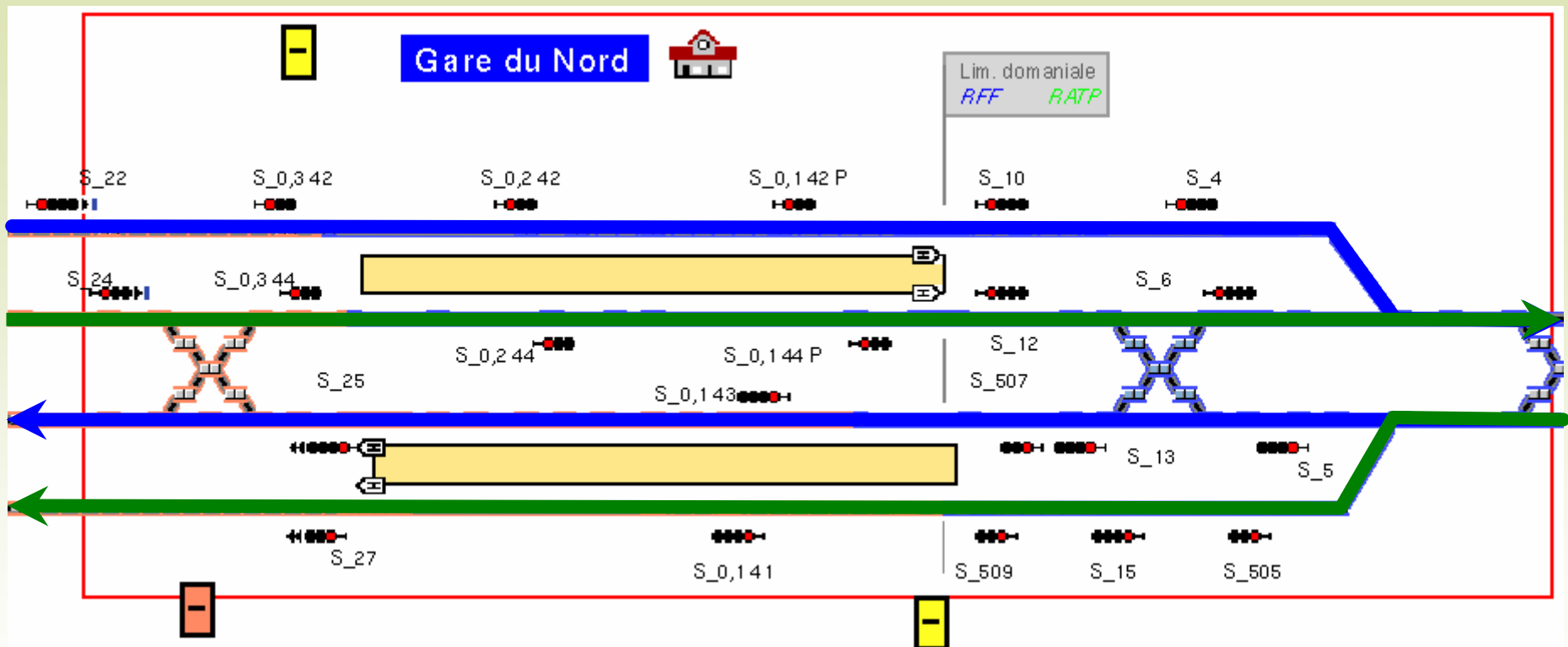


# 3. Main technical data

17/09/07 January 24<sup>th</sup>, 2008



Focus on station : Gare du Nord



(north) La Plaine Stade de France ⇌  ⇌ St Michel Notre Dame (south)

(north) Stade de France – St Denis ⇌  ⇌ Paris Gare de Lyon (south)



## 4. Major stakes

17/09/07 January 24<sup>th</sup>, 2008



- ☞ Dense traffic → one of the most heavily occupied railway sections in France
  - ☞ 32 trains per hour and per direction
  - ☞ Gare du Nord + Châtelet les Halles : 2 major nodes in Paris network
- ☞ Signalling system in the tunnel
  - ☞ Classic signal system : fixed block 3 aspects signalling
  - ☞ Continuous Speed Control → acceleration authorised before signal sighted
  - ☞ Different driving behaviour between SNCF and RATP personal
- ☞ Change of conductor in Gare du Nord
  - ☞ Dwell time : 2 minutes in reality, instead of 1 minute in timetable
- ☞ Major goals for regularity
  - ☞ Intention of Transport Authority : allowing more trains on the line each hour
  - ☞ Today : every peak hour, 2 trains cancelled by direction



# 5. Before simulating : Present situation

17/09/07 January 24<sup>th</sup>, 2008



Diagnostic and analysis of present operations, normal situation without major disturbances

## ☞ Theoretical timetable

- ☞ Number of trains
- ☞ Different headways (ex : a train every 3 min for line B)
- ☞ Identification of peak hours

**32 trains  
p.h.p.d.  
in theory**

## ☞ Real operating data (statistics concerning a representative period)

- ☞ Distribution of delays on arrival at stations
- ☞ Distribution of dwell times
- ☞ Use of track Z in Châtelet station
- ☞ Headways between trains

**25 trains  
p.h.p.d. in  
reality**

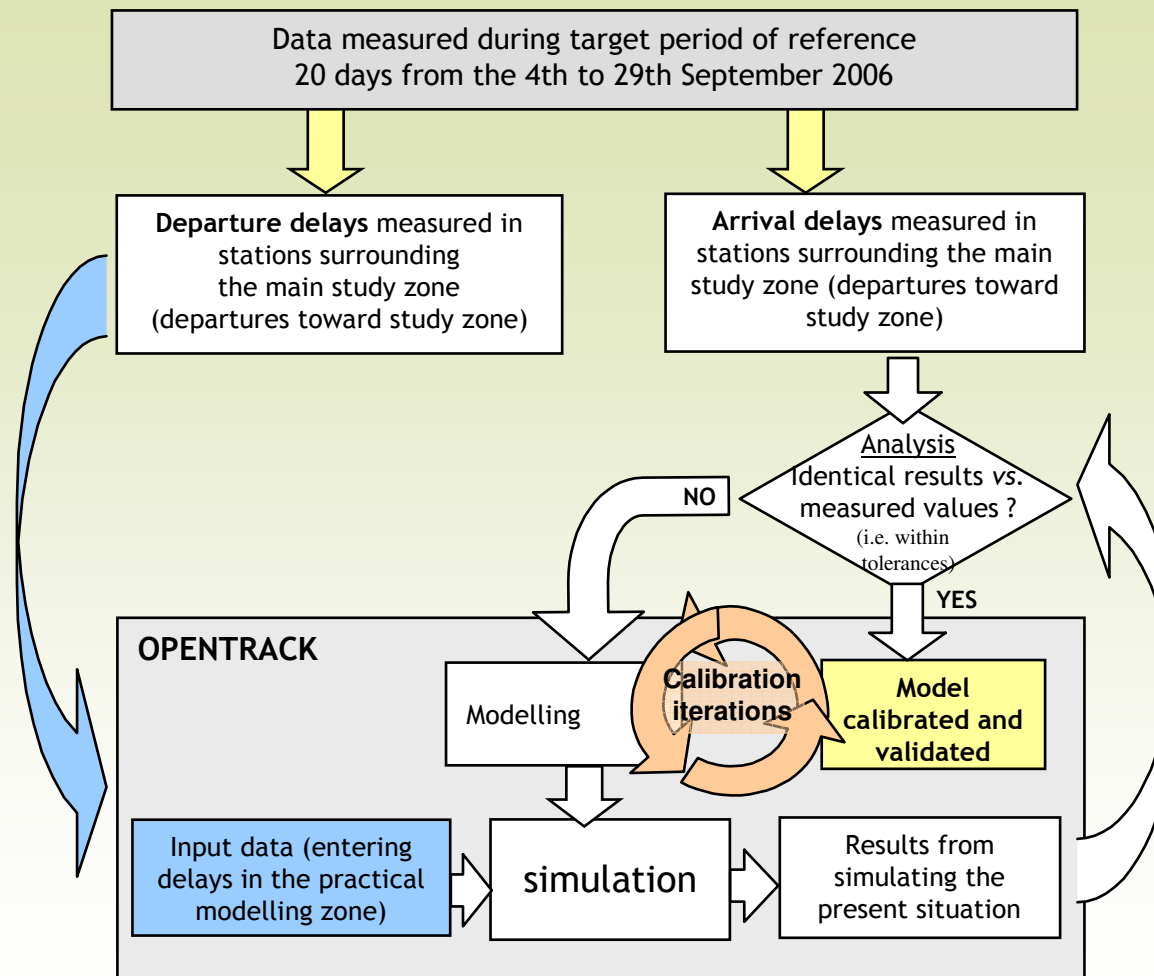
## ☞ Site visits

- ☞ Tracks
- ☞ Interlocking posts
- ☞ Cab rides



# 5. Model calibration chart

17/09/07 January 24<sup>th</sup>, 2008





# 5. Before simulating : Model calibration

17/09/07 January 24<sup>th</sup>, 2008



## ☞ Basic definition

- ☞ Infrastructure (tracks, station platforms, speeds, signals, routes settings)
- ☞ Rolling stock (types and performances)
- ☞ Timetable

## ☞ Calibration method

- ☞ Extended peak hours, 06.00 - 10.00
- ☞ Filtering of circulations : from 5560 trains planned to 4920 trains used (data considered reliable)
- ☞ 20 simulation runs

## ☞ Calibration criteria

- ☞ Shortened peak period : 07.15 - 09.15
- ☞ Filtering of circulations : from 4920 trains to 2145 trains in that specific period
- ☞ Delays on arrival at stations (Average, standard deviation, correlation)



# 5. Before simulating : Reference

17/09/07 January 24<sup>th</sup>, 2008



- Based on the calibrated model
  - All trains within the theoretical timetable
  - Infrastructure unchanged
  - Modification of injection rules for line B South > North
- Evaluation criteria of reference (also used to evaluate scenarios)
  - Peak hour capacity
  - Overall delay for each line, end of main study zone
  - Mean delays + standard deviation



## 6. Simulation in several steps : scenarios

17/09/07 January 24<sup>th</sup>, 2008

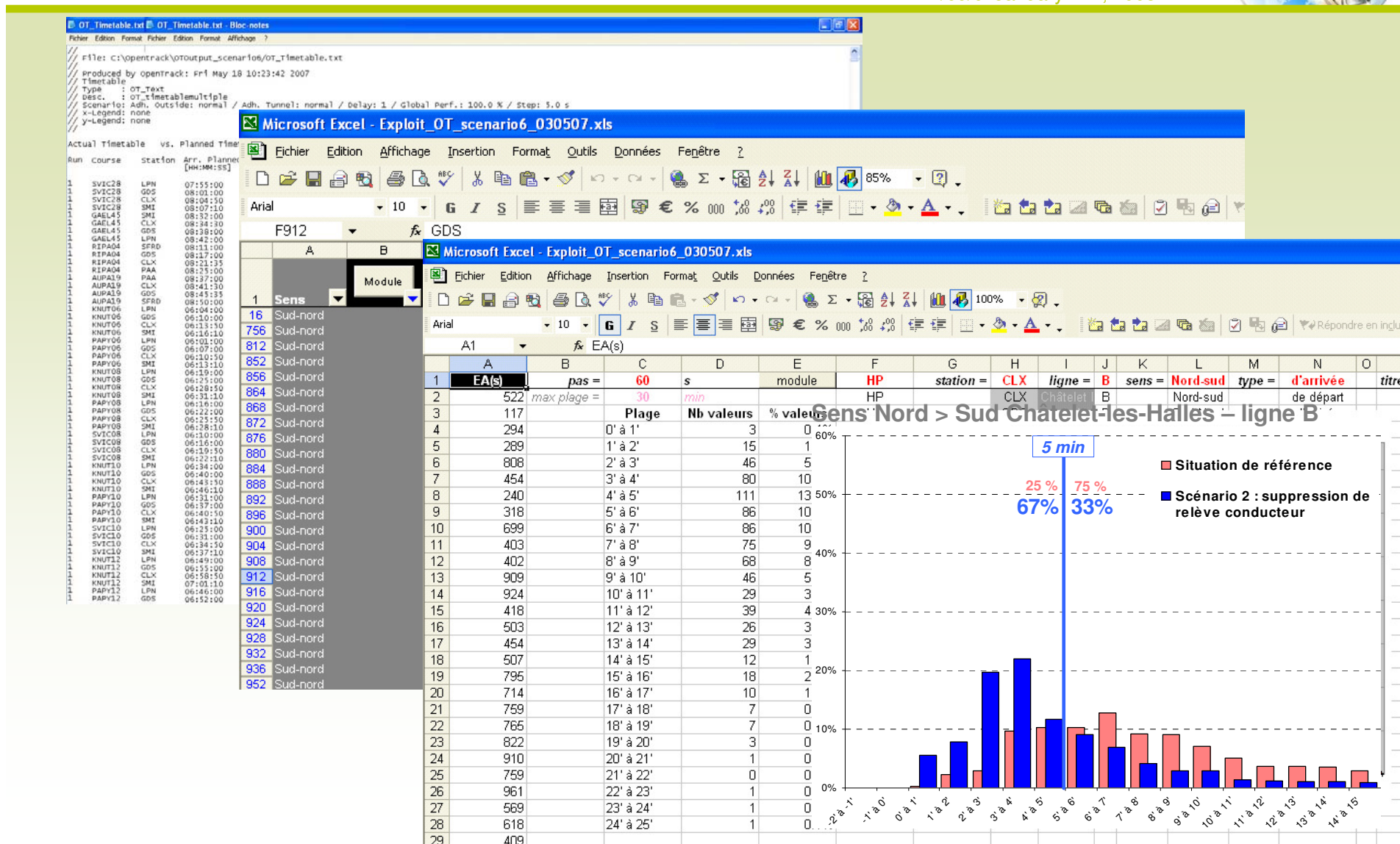


- ☞ Modelling of the following parameters, according to the scenario
  - ☞ Infrastructure
  - ☞ Initial delay (piecewise linear distribution)
  - ☞ Timetable and dwell times
  - ☞ Rolling stock
- ☞ Visualisation on screen ➔ check of correct modelling
- ☞ Simulation : 20 runs for each scenario, without visualisation
- ☞ Statistical analysis
  - ☞ « OT\_timetablestatistics.txt » file, wasn't helpful, only the last run recorded
  - ☞ Our partner, Mr Huerlimann developped a new file with the listing of 20 runs
  - ☞ Direct use of the Excel file in a specific Excel based program



# 6. Outputs ...

17/09/07 January 24<sup>th</sup>, 2008



# 7. Interesting scenarios

17/09/07 January 24<sup>th</sup>, 2008



- ☞ Short term scenario : Turnaround at Châtelet-les-Halles using track Z
  - ☞ Line RER D : lower traffic in the tunnel
    - 4 trains / 12 stop at Châtelet les Halles, on a dedicated track (voie Z)
    - 8 trains remaining in the tunnel each hour
  - ☞ Line RER B : all trains continuing in the tunnel (20 each peak hour)
  
- ☞ Short term scenario : Suppression of driver change
  - ☞ Only line B concerned, today both operated by SNCF and RATP in their perimeter
  - ☞ Harmonization of driving behaviors in the tunnel (start on « yellow » warning signals)
  - ☞ Reduction of dwell times for RER B in Gare du Nord (= Châtelet times)



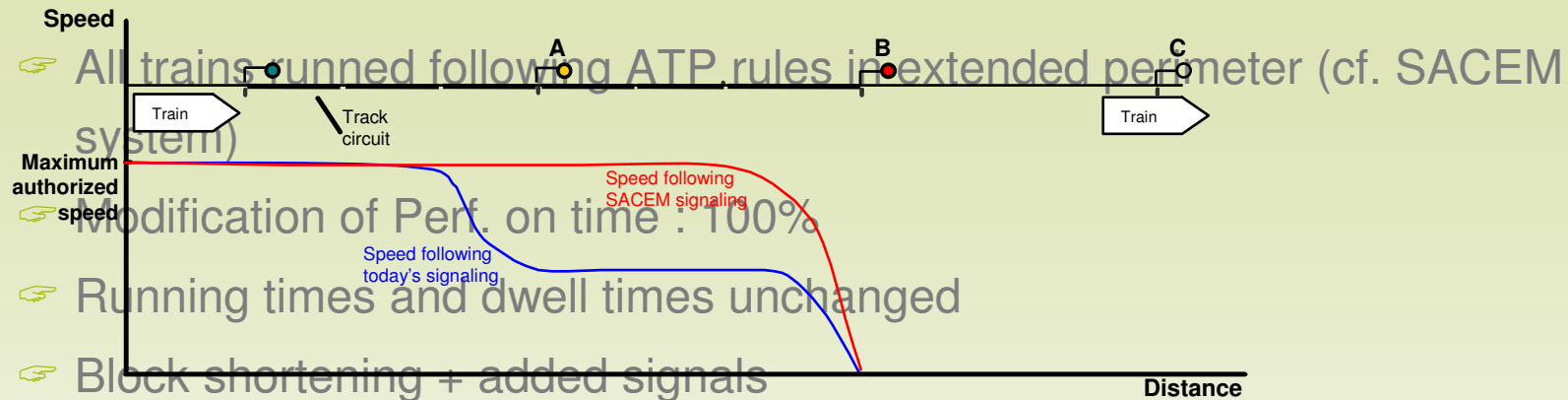


# 7. Interesting scenarios

17/09/07 January 24<sup>th</sup>, 2008



## Mid term scenario : Automated driving



## Rail switch in Gare du Nord

- > South : allowing RER B on tracks originally dedicated to RER D
- > North : possible track interchange for both line
- Running times and dwell times unchanged
- Adding priorities



# 8. Conclusion

17/09/07 January 24<sup>th</sup>, 2008



## ☞ Specificity of the study

- ☞ 40 modelled scenarios with OT (27 « officialy » ordered by client)
- ☞ A 18 months study, 6 sessions of simulation
- ☞ OT : a tool for concensus between authority and operators
- ☞ Statistical approach of the problem

## ☞ Possible improvements

- ☞ Different boarding-unboarding times according to rolling stock
- ☞ Interface with other simulation software (i.e. : Simwalk)
- ☞ Definition of crowds on platform : impact on dwell times



End ...

17/09/07 January 24<sup>th</sup>, 2008



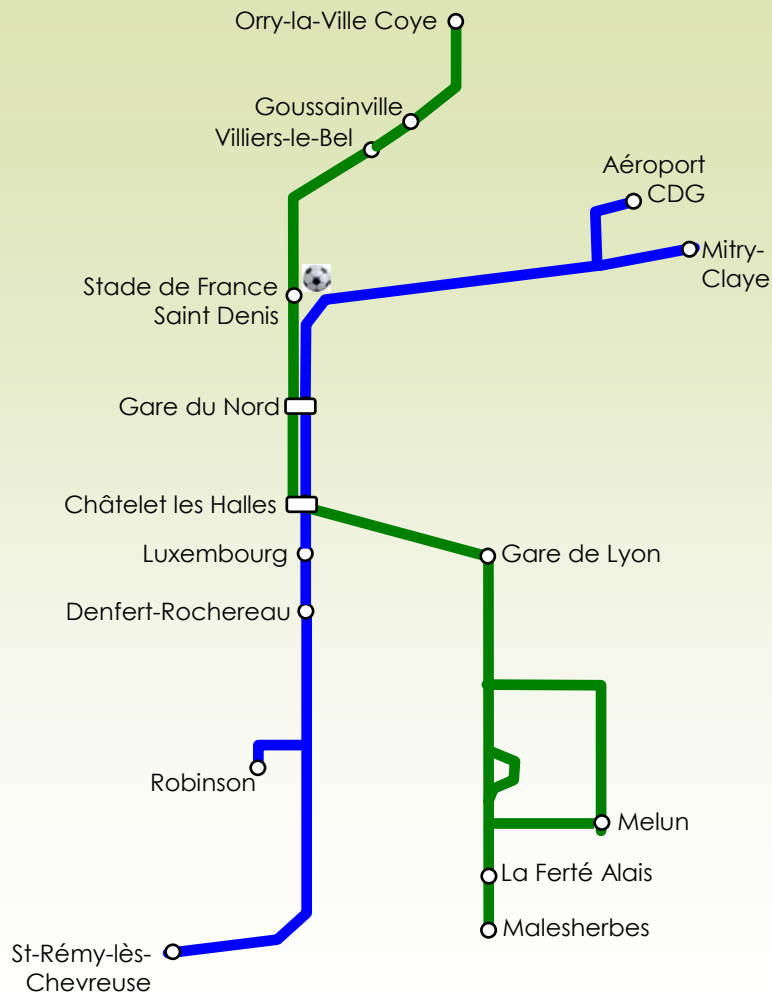
Thank you for your attention !!!

I'm available for your questions



# Brief history of line RER B and RER D

17/09/07 January 24<sup>th</sup>, 2008



- ➡ **From 1846 : historical « ligne de Sceaux » ending first at Denfert-Rochereau, later at Luxembourg,**
- ➡ **1977 : continuation under the Seine river, until Châtelet les Halles,**
- ➡ **1981 : opening of the Châtelet – Gare du Nord tunnel**
- ➡ **1983 : junction with Roissy-Rail airport courses and the Mitry – Gare du Nord line = today's line B**
- ➡ **1987 → 1990 : trains coming from Villiers le Bel, Goussainville and Orry la Ville stopping first at Gare du Nord, extended at Châtelet les Halles (via existing tunnel)**
- ➡ **1995 : opening of the Châtelet – Gare de Lyon underground section, trains heading toward Melun, La Ferté-Alais and Malesherbes**
- ➡ **1998 : opening of Stade de France Saint-Denis station**



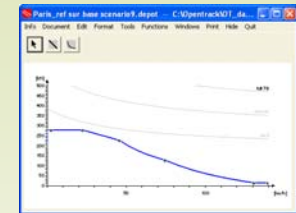


# Rolling stock involved in the tunnel

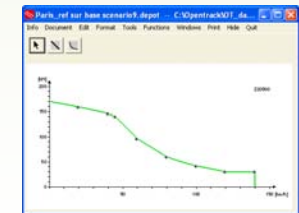
17/09/07 January 24<sup>th</sup>, 2008



- Date of construction : 1980-1983
- V max : 140 km/h
- Max passenger capacity : 843 p.
- Length : 104 m
- Weight : 283 T
- Concerned line : RER B  
*(also running on line A)*

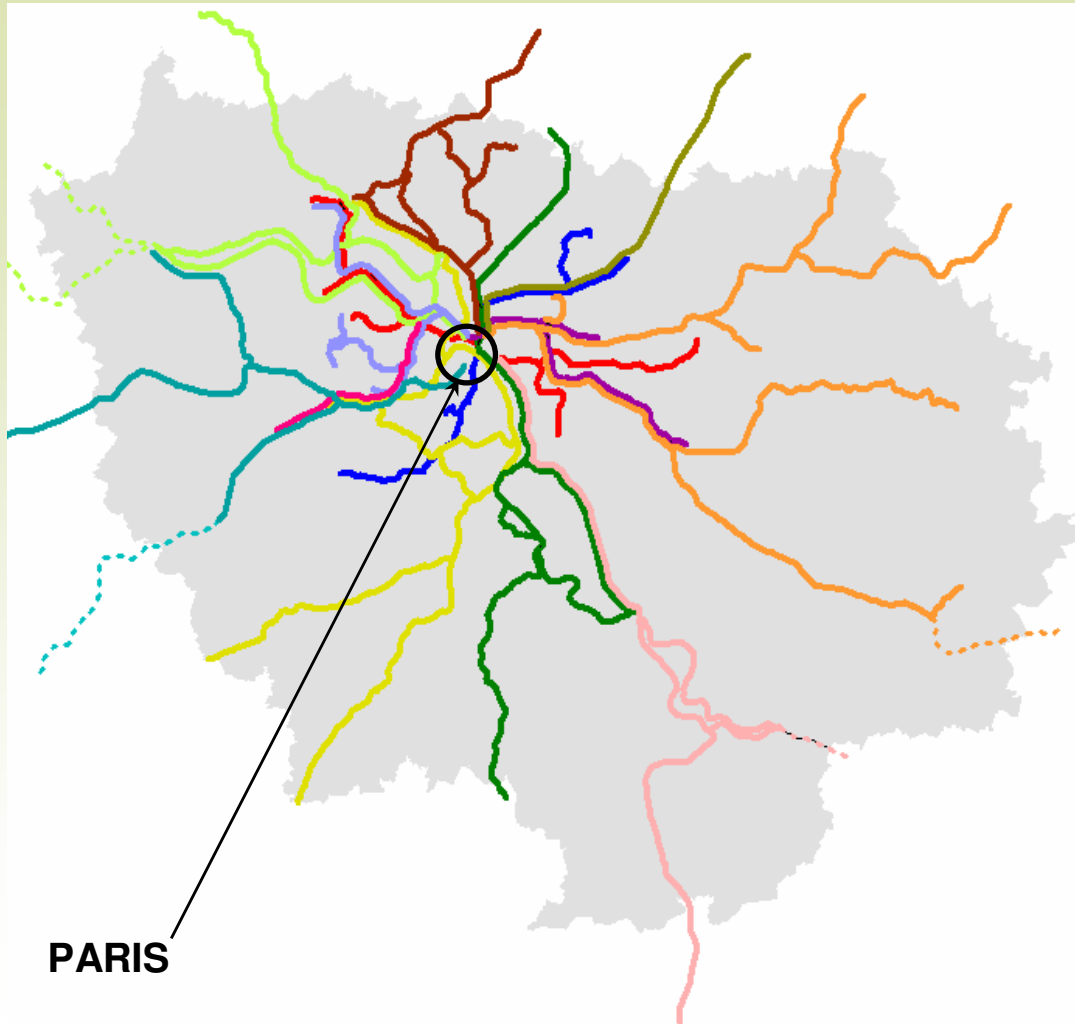


- Date of construction : 1988 - 1998
- V max : 140 km/h
- Max passenger capacity : 1413 p.
- Length : 129 m
- Weight : 381 T
- Concerned line : RER D



# Ile-de-France regional rail network

17/09/07 January 24<sup>th</sup>, 2008



- Réseau Express Régional
- Strong and identified network
- Paris underground cross-over
- 2 operators : RATP + SNCF



- SNCF operation (Transilien)
- Basic commuter lines
- Terminus in 6 main stations
- Possible shared trunks with RER lines



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17/09/07 January 24<sup>th</sup>, 2008



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